

**AN INVESTIGATION OF WATER QUALITY CHARACTERISTICS OF UPPER
KAFUBU RIVER IN NDOLA, ZAMBIA**

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APPROVAL

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DEDICATION

To my beloved husband Nkaka and my daughters Mutale and Tsitsi

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ABSTRACT

This study analysed the physico-chemical and bacteriological characteristics of water in the Upper Kafubu River basin in terms of temporal and spatial variations in the period 1991-1999. The effects of urban activities on the physico-chemical and bacteriological regimes of the Kafubu River in Ndola were also assessed. The studied Kafubu River basin is 60 km² in size and originates from the Zambezi-Congo watershed. Analysed data included archival water quality data for sampling stations operated by the Ndola City council, water level and discharge data for Kafubu River, supplied by Water Affairs and rainfall measurements from Ndola Airport rainfall station. These data were supplemented by field measurements in the 1998/1999 season. Six sampling points were located along the whole stretch of the urbanised reach of Upper Kafubu River over distance of about 20 km from Itawa Swamps Railway Bridge in the northeast to Kafubu Dam in the southwest. Physico-chemical characteristics were determined by standard laboratory techniques at Kanini and Indeni laboratories in Ndola. Parameters analysed included temperature, colour, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), turbidity, taste, odour, conductivity, pH, total alkalinity, total hardness, calcium and magnesium hardness, chlorides, and Chemical Oxygen Demand (COD).

The results of analysis showed that, crude and minimally treated municipal and industrial effluents from sewage treatment plants and industries grossly polluted the Upper portion of Kafubu River. This was evidenced by high mineralization of river water such that TDS values averaged between 218.7 to 326.35 ppm, average conductivity (328.0 to 491.88 μ mhos/cm), average pH of between 7.2 and 8.96 units, average total alkalinity and hardness of between 152.2 to 259.04 ppm and 133.28 to 294.88 ppm, respectively, were recorded. Trace metal concentrations that included lead (0.035 to 1.58 ppm) zinc (0.03 to 1.0 ppm) and copper (0.02 to 0.34 ppm) with lead exceeding the maximum allowable limit of 0.5 ppm in river water, were observed. Anion and cation transport were highest in the upstream stations at Itawa Swamps and Itawa Dam, which probably resulted from increased chemical decomposition and runoff associated with rain events such that solute transport was more pronounced during wet (November to March) than dry season (April to October). In contrast, the concentration levels of suspended

sediment concentration (SSC), chemical oxygen demand (COD), turbidity, colour, taste and odour were typically highest in the downstream stations (ST4 and ST5) and were more pronounced during dry season (April to October). Concentration levels of lead colour, pH, and at times SSC, turbidity, taste and odour were above ECZ (1993) maximum permissible levels for streams receiving wastewaters. The concentration levels of parameters such as TDS, conductivity, total hardness and alkalinity, calcium and magnesium hardness, copper and zinc were relatively high though within permissible levels for an effluent receiving stream used for subsequent production of drinking water. Similarly, the quality of treated water in terms of lead, colour, taste and odour, and at times turbidity, TSS and alkalinity concentration levels at both Itawa and Kafubu water works were above maximum allowable levels. Raw and treated river water in the Upper Kafubu catchment was alkaline and hard throughout the study period.

Organic pollution was evident with high chemical oxygen demand (COD) (39.73 to 65.66 ppm) in river water and also with the occurrence of high number of coliform bacteria (0 to 18 / 100 mls) and the presence of *E. coli* in treated water. The total coliform organisms and *E. coli* were present in most of the treated water samples at both water works indicating that tap water had pathogens which could cause health risks to consumers of this water. This was because chemical additive dosage levels used were insufficient for effective water treatment. Thus, it was deduced that non-continuous granular chlorine additive dosage and the low aluminum sulphate and the copper sulphate dosage, contributed to the presence of coliform bacteria and *E. coli*, excessive colour, and bad taste. The obsolete infrastructure, such as clogged sand filters contributed to the unwholesomeness of tap water especially at Kafubu Water Works.

It is concluded that a combination of temporal, spatial, hydrological and climatological factors control variations in water quality of Upper Kafubu River basin in a complex fashion. Therefore, with more data, multivariate analysis of the aforementioned factors should greatly improve prediction of river quality in Upper Kafubu River basin.

TABLE OF CONTENTS

Approval.....	(i)
Dedication.....	(ii)
Acknowledgements.....	(iii)
Abstract.....	(v)
Table of Contents.....	(vii)
List of Tables.....	(xi)
List of Figures.....	(xii)
List of Appendices.....	(xvi)
CHAPTER 1: INTRODUCTION.....	1
1.1 Introduction.....	1
1.2 Background to the Study.....	3
1.3 Research Objectives.....	4
1.4 Scope.....	4
CHAPTER 2: LITERATURE REVIEW.....	8
2.1 Introduction.....	8
2.2 Water Quality at Global Level.....	8
2.3 Quality of Zambian River Waters.....	10
2.3.1 Water Quality Characteristics in the Kafue River Basin.....	12
2.4 Water Pollution Control Standards in Zambia.....	16
2.5 Legal Framework for Commercial Utilities in Zambia.....	17
CHAPTER 3: THE STUDY AREA.....	19
3.1 Location and Size.....	19
3.1.1 Topography.....	19
3.1.2 Geology.....	21
3.1.3 Climate.....	23
1.4 Hydrology.....	23
3.2 Vegetation and Landuse.....	24
CHAPTER 4: METHODOLOGY.....	26

4.1	Introduction.....	26
4.2	Types and Sources of Secondary Data.....	26
4.3	Primary Data Collection.....	27
4.3.1	Water Levels and Discharge Measurements.....	27
4.3.2	Field Observations and Water Sample Collection.....	28
4.4.1	Sampling Points.....	29
4.4.1.1	Itawa Swamps Station (ST1).....	29
4.4.1.2	Itawa Dam Station (ST2).....	32
4.4.1.3	Itawa Water Works Station (ST3).....	32
4.4.1.4	Kanini Station (ST4).....	34
4.4.1.5	Kafubu Dam Station (ST5).....	34
4.4.1.6	Kafubu Water Works Station (ST6).....	34
4.5	On-Site Sampling Procedure.....	37
4.6	Water Quality Determination.....	37
4.6.1	Measurements of Physical Parameters.....	38
4.6.1.1	Temperature, Colour, Turbidity and Conductivity.....	38
4.6.1.2	Total Suspended Solids (TSS) and Total Dissolved Solids (TDS).....	39
4.6.2	Measurements of Chemical parameters.....	39
4.6.2.1	pH, Chemical Oxygen Demand (COD), Magnesium hardness (CaCO ₃), Calcium hardness (CaCO ₃), Total hardness, Total Alkalinity, and chlorides.....	39
4.6.3	Trace Metals.....	40
4.7	Quantitative Analysis Methods.....	40
4.8	Limitations.....	41
CHAPTER 5: RESULTS AND ANALYSIS.....		42
5.1	The Hydrological Regime of Kafubu River.....	42
5.1.1	Stream Hydrograph and Hyetograph Characteristics.....	44
5.2	River Water Quality.....	46
5.2.1	Physical Characteristics of River Water.....	49
5.2.1.1	Temperature.....	49
5.2.1.2	Total Suspended Solids (TSS).....	50
5.2.1.3	Total Dissolved Solids (TDS).....	52

5.2.1.4	Conductivity.....	55
5.2.1.5	Turbidity and Colour of Water.....	56
5.2.2	Chemical Characteristics of River Water.....	59
5.2.2.1	pH.....	59
5.2.2.2	Total Alkalinity.....	60
5.2.2.3	Calcium, Magnesium and Total Hardness.....	63
5.2.2.4	COD and Chlorides.....	63
5.2.3	Trace Metal Concentrations in Raw River Water.....	66
5.3	Treated (tap) Water Quality Characteristics.....	70
5.3.1	Physico-Chemical Characteristics of Treated Water.....	70
5.3.2	Bacteriological Characteristic of Drinking Water.....	79
5.4	Quality of Wastewaters Discharged into the Kafubu River.....	82
5.4.1	Municipal Wastewaters.....	82
5.4.2	Characteristics of Industrial Wastewaters.....	88
5.4.2.1	Treatment of Industrial Wastewaters at Zambezi Paper Mills Limited.....	90
5.4.2.2	Treatment of Industrial Wastewaters at Textile Mills.....	91
5.4.2.3	Treatment of Industrial Wastewaters at Lever Brothers Zambia Limited.....	93
5.4.2.4	Treatment of Industrial Wastewaters at Colgate Palmolive Zambia Limited.....	94
5.4.2.5	Treatment of Industrial Wastewaters at Zambia Oxygen Limited (ZAMOX).....	94
5.4.2.6	Treatment of Industrial Wastewaters at Lyons Brooke Bond Zambia Limited.....	95
5.4.2.7	Treatment of Industrial Wastewaters at Ndola Lime Mine Area.....	96
CHAPTER 6: DISCUSSION, INTERPRETATION AND IMPLICATIONS.....		97
6.1.	Introduction.....	97
6.2	Seasonal Characteristics of River Water Quality.....	99
6.2.1	Wet Season.....	99

6.2.2	Dry Season	104
6.2.3	Implications.....	109
6.3	Seasonal Variations in Physico-chemical Quality of Treated Water.....	112
6.3.1	Wet Season Characteristics.....	112
6.3.2	Dry Season Characteristics	113
6.3.3	Implications	118
6.3.3	Evaluation of Water Treatment Efficiency for Physico-chemical Constituents in River Water.....	118
6.3.4	The Bacteriological Characteristics of Treated (Tap) Water.....	121
6.4	Conclusion.....	123
CHAPTER 7: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS.....		125
7.1	Summary.....	125
7.1.1	Physico-chemical Characteristics.....	125
7.1.2	Trace Metal Contamination.....	127
7.1.3	Bacteriological Contamination of Treated Water.....	127
7.1.4	Characteristics of Wastewaters from Municipal and Industrial Activities.....	128
7.2	Conclusions.....	128
7.3	Recommendations.....	130
8.0	References.....	132
9.0	Appendices.....	137

LIST OF TABLES

Table 5.1:	Wet Season Physico-chemical Characteristics of raw River water in the Upper Kafubu River 1998).....	47
Table 5.2:	Dry Season Physico-chemical characteristics of raw River Water in the Upper Kafubu River (1998).....	48
Table 5.3:	Temperature Variations in Raw and Treated Water in The Upper Kafubu River Basin in Ndola (°c).....	50
Table 5.4:	Total Dissolved Loads in the Upper Kafubu River Basin ,Ndola.....	53
Table 5.5:	Physico-chemical Characteristics of Treated Water at Itawa and Kafubu Water Works in the Wet Season.....	71
Table 5.6:	Physico-chemical Characteristics of Treated Water at Itawa and Kafubu Water Works in the Dry Season.....	72
Table 5.7:	Coliform Bacteria, Taste, Odour, and Appearance of Water in relation to Residual Chlorine Concentration Levels at Itawa and Kafubu Water Works and their Distribution Systems (1998/99)	80
Table 5.8:	Percentage of Occurrence of Total Coliforms and <i>E. coli</i> in Treated water works and their Distribution Systems in Relation to Residual Chlorine Concentrations (1991/98)	81
Table 5.9:	Results of Laboratory analysis for Sewage Effluents Collected at Sewage Outflows in Ndola.....	83
Table 5.10:	Mean values of Percentage Removal of Sewage Works in Ndola	88
Table 5.11:	Listing of Major Industries in Ndola: their Products, Potential Pollutants to Kafubu Aquatic Environment and Pre-treatment Processes.....	89
Table 6.1:	Regression Equations for Estimating Trace Metal Concentrations From River Discharge.....	108
Table 6.2:	Results of t-test on the Effectiveness of Itawa and Kafubu Water Treatment Plants.....	120

LIST OF FIGURES

Figure 1.1	Location Map of Ndola in Zambia	2
Figure 3.1	Map Showing the Topography and Drainage Network of Upper Kafubu River Basin	20
Figure 3.2	Map Showing the Geology of the Upper Kafubu River Basin.....	22
Figure 4.1	Map Showing the Water Sampling Stations along Kafubu River in Relation to Major Economic Activities in Ndola Town.....	30
Figure 4.2	Kafubu River at Itawa (a) Itawa Swamps (ST1), (b) Itawa Dambo, a Low Earth Dam Providing Raw River to Itawa Water Works	31
Figure 4.3	Itawa Water Works Sampling Station for Raw and Treated Water (a) Intake point from Itawa Dam (ST2) and (b) tap Water Within the water Works (ST3).....	33
Figure 4.4	Kafubu River at Kanini Foot-Bridge (a) Kanini Sewage Works on the Western bank of Kafubu River (b) Kanini Foot-Bridge (ST4)	35
Figure 4.5	Kafubu Water Works Sampling Stations (a) Intake point from Kafubu Dam into the Water Treatment Plant (ST5), (b) Tap Water (ST6) Located within Kafubu Water Treatment Plant	36
Figure 5.1	Hydrological (a) and Rainfall (b) Regimes of Kafubu River in Ndola in the period 1997-1998, respectively.....	43

Figure 5.2	Plot of hyetograph and hydrograph for Kafubu River 1993-1998.....	45
Figure 5.3	Temporal Variations in Sediment Concentration Levels in Raw River Water in Upper Kafubu Catchment (a) TSS (ST1) and (ST4), (b) TDS (ST1) and (ST4), (c) TSS (ST2) and (ST5), and TDS (ST2 and (ST5)	51
Figure 5.4	Relationship between estimated Discharge and measured total dissolved load at (a) Itawa Swamps (ST1) and (b) Kanini (ST4), 1998, Ndola.....	54
Figure 5.5	Temporal Variations in Conductivity Concentration levels in Kafubu River Water at (a) Itawa Swamps (ST1) and Kanini (ST4), and (b) Itawa (ST2) and Kafubu (ST5) Dams.....	57
Figure 5.6	Turbidity and Colour Units in Raw River Water in Upper Kafubu Catchment (a) Turbidity (ST1) and (ST4), (b) Colour Units (ST1) and (ST4), (c) Turbidity (ST2 and ST5) (d) Colour Units (ST2) and (ST5)	58
Figure 5.7	Temporal Variations in pH Units in River Water at (a) Itawa Swamps (ST1) and Kanini (ST4), (b) Itawa (ST2) and Kafubu (ST5) Dams	61
Figure 5.8	Temporal Variations in Total Alkalinity Concentration Levels in Raw River Water at Itawa Swamps (ST1) and Kanini (ST4) Itawa (ST2) and Kafubu (ST5) Dams	62
Figure 5.9	Temporal Variations in Concentration Levels of (a) Total Hardness, (b) Calcium Hardness, (c) Magnesium Hardness, (d) Total Hardness, (e) Calcium Hardness and (f) Magnesium Hardness in Raw River Water in Upper Kafubu Catchment	64

Figure 5.10	Temporal Variations in COD Concentration Levels in Raw River Water at (a) Itawa Swamps (ST1) and Kanini (ST4), (b) Itawa (ST2) and Kafubu (ST5) Dams.....	65
Figure 5.11	Temporal Variations in Concentration Levels of Chlorides in Raw River Water at (a) Itawa Swamps (ST1) and Kanini (ST4), (b) Itawa (ST2) and Kafubu (ST5) Dams	67
Figure 5.12	Temporal Variations in Concentration Levels of (a) Lead, (b) Copper (c) Zinc in Raw River Water in the Upper Kafubu River Basin.....	69
Figure 5.13	Temporal Variations in Concentration Levels of (a) Colour (b) Total Suspended Solids and (c) Total Dissolved Solids in Drinking Water at Itawa and Kafubu Water Works	73
Figure 5.14	Temporal Variations in Concentration Levels of (a) Turbidity, (c) Conductivity (c) Chlorides, and (d) pH in Drinking Water at (d) Itawa and Kafubu Water Works	75
Figure 5.15	Temporal Variations in Concentration Levels of (a) Total Alkalinity and (b) Total Hardness in Treated Water at Itawa and Kafubu Water Works.....	77
Figure 5.16	Temporal Variations in Concentration Levels of (a) Lead, (b) Copper and (c) Zinc in Drinking Water at Itawa and Kafubu water works	78
Figure 5.17	Graphs Showing TSS, SDS, and Conductivity Concentration Levels in effluents from (a) Old Kanini (b) New Kanini	